BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI
ADVANCED PHYSICS LAB
Comprehensive Examination 2021-22 II semester
Advanced Physics Laboratory
Closed Book 90 marks 17th May 2022

- Questions from Section A (30 marks) should be answered in the answer-sheet provided. Write section A on the answer-sheet
- Questions from Section B (30 marks) should be answered in a separate answer-sheet. Write section B on this answer-sheet
- *Section C (30 marks): Final answer should be written clearly in the box provided with each questions. Write your name, ID & signature on the question paper of Section C. Detach the Section C and submit along with two answer-sheets for section A and B.*
- Answer all questions in respective section and in sequence ONLY.

Exchange of calculators strictly not allowed.

You may require: k_B = 1.38 x 10^{-23} J/K, 1eV = 1.6 x 10^{-19} J, ε_0=8.854×10^{-12}F/m, h = 6.62 x 10^{-34} J-s

Section A: Nanoscience lab (30 marks)

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Answer all questions in same sequence. Each question carry 5 marks [5M×6 = 30M]

Q1. Two separate vacuum deposition units can reach to vacuum levels of 3×10^{-6} mbar and 5×10^{-6} mbar, respectively. If the mean free path of metal vapour atoms during the deposition is found to be 30 cm in Unit-1, what will be maximum possible dimension of the Unit-2 chamber?

Q2. (a) Write two advantages and disadvantages of E-beam evaporation over thermal evaporation technique for thin film deposition (only scientific/technical points). (b) Also write one technical advantage of AC magnetic susceptibility measurement over the DC measurement

Q3. Electrical conductivity and electron mobility for copper are 3×10^6 $(\Omega\text{-m})^{-1}$ and 0.01 m^2/V-s, respectively. Find the Hall voltage generated within a copper sheet of thickness 2 mm when a current of 30 A flows and a magnetic field of 1 T is applied mutually perpendicular to that. [electronic charge e =1.6×10^{-19} C]

Q4. What are the main external parameters that can influence the resistivity of a thin metal films and how? [only with bulleted points]

Q5. A material is placed in an external magnetic field of 10 units and shows a magnetization of 60 units. Find the magnetic permeability μ_m and flux density *B* of the material. [Given that free space permeability μ_0 = 1 unit]

Q6. Choose the correct alternative/s

(a) AC magnetic susceptibility of a ferromagnetic material varies with external magnetic field frequency as
(i) Remains constant at lower frequency and increases at higher frequency
(ii) Remains constant at lower frequency and decreases at higher frequency

(iii) Increases at lower frequency and decreases at higher frequency
(iv) Decreases at lower frequency and increases at higher frequency

(b) The magnetic susceptibility χ_m of the following materials is compared as

(i) Ferro Mag. > Para Mag. > Dia Mag. > Vacuum
(ii) Ferro Mag. > Para Mag. > Vacuum > Dia Mag.
(iii) Ferro Mag. > Vacuum > Para Mag. > Dia Mag.
(iv) Ferro Mag. < Para Mag. < Vacuum < Dia Mag.

Section B: Microwave, Materials and Liquid Crystal Labs (30 marks)

Q.1. What is electrical and mechanical tuning of a klystron tube? Write in brief. [**2+2**]

Q.2. Draw (side view) a clear design of the set up to measure H-plane characteristic of pyramidal horn antenna within the radiation zone approximately from -50^0 to 50^0. [**2]**

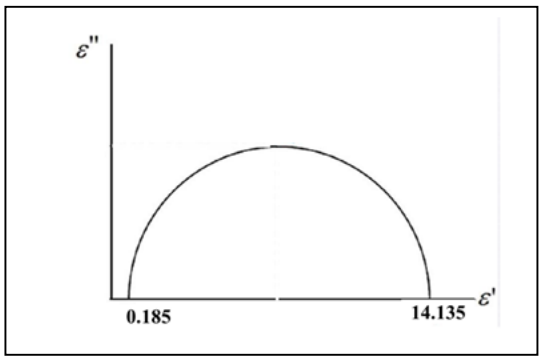
Q.3. Calculate the wavelengths of microwaves represented as λ_{21}, λ_{22}, λ_{13} and λ_{31} for microwave propagation in TE mode inside a rectangular waveguide of H- and E- plane dimensions are 3cm and 2.5 cm respectively. Write only the value of λ in cm. No need to show the derivations/calculations. [**4**]

Q4. (i) For which set of crystallographic planes will a first order diffraction peak occur at a diffraction angle (2θ) of 44.53° for FCC Nickel (consider λ = 0.154 nm and lattice parameter is 0.353 nm). (ii) If the crystallite size for this peak is 40 nm, what should be the width of the peak at 2θ value of 44.53°? (iii) What should be the peak positon (in 2θ) for (200) peak? **[4+3+3]**

Q5. a) Calculate the electric field (in V/m) required to produce the polarization of 10 nC/m^2 in the medium of dielectric constant = 9. (Given, $\varepsilon_0 = 8.854\times10^{-12}$ F/m) **[3M]**

b) A light of wavelength 632 nm passes through a planar aligned nematic LC cell of thickness 10μm kept between crossed polarizers. If the phase retardation ($\Delta\phi$) due to this nematic LC cell is 25 radians at 25 ^{o}C, calculate the birefringence ($\Delta\mu$) of the nematic LC. **[3M]**

c) Calculate the value of complex dielectric permittivity at 10 kHz of the LC medium showing relaxation at 5 MHz as shown in Figure. Assume this to be Debye type relaxation (absorption coefficient α=0). **[4M]**



Section C (to be returned)
Surface Science Lab (30 marks)
Write the final answer in the box

Name:
ID:
Signature:
Marks Obtained:

1. At which state of polarization of light incidenting at a given interface at its Brewster angle vanishes on reflection i.e. reflected intensity becomes zero?

ANS (2M):

2. In ellipsometry experiment, if the value of P1 is 43^o for null condition one, what will be correct value of P2 in the second null condition?

ANS (2M):

3. Which mode of operation of STM does not require feedback control?

ANS (2M):

4. In ellipsometry experiment, write the equation relating the ellipsometric parameters with that of Fresnel's reflection coefficient.

ANS (2M):

5. In ellipsometry experiment, if P1, P2 are 26^o and 296^o respectively, what is the value of Δ?

ANS (3M):

6. As stated in question 5, additionally if A1 and A2 are 112^o and 270^o respectively, what is the value of Ψ?

ANS (3M):

7. In QCM experiment, what is the value of sensitivity constant C (proper units), if data collected during sensing is as shown in the table below:

Sl no	Concentration (ppm)	Δf (Hz)	Δm ($\mu g/cm^2$)
1	119	-28	8.23
2	153	-36	10.59

ANS (4M):

8. What is the sensitivity of QCM (with proper units) as obtained from the calibration curve during sensing as shown in the Table above?

ANS (4M):

9. The potential of interaction between the tip and the sample is defined by $U = \frac{42C}{r^8} - \frac{88D}{r^4}$ where *C* and *D* are constants and *r* is the tip-surface separation. Find the distance (in terms of *C* and *D*) between tip-surface for which the tip will feel equilibrium force.

ANS (4M):

10. If the light is incidenting from water (refractive index=1.33) to a glass medium (refractive index=n) and the Brewster angle is found to be 58.5^o, what is the value of n?

ANS (4M):

----------All the best----------